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**USE OF RUBBER BAGS IN GAUGING CRANIAL
CAPACITY¹**

WASHINGTON MATTHEWS

Some months ago, in some one of the scientific periodicals, I have forgotten which, I saw a brief notice of a method of gauging the cranial capacity by means of introducing an india-rubber bag into the cranial cavity and filling the bag with water. The method was heralded as new, as nearly or quite faultless, and the original invention was attributed to Mr H. Poll, a medical student of Berlin.

I knew at the time that there was nothing novel in the system, that Mr Poll was not the original inventor, and I believed that the method had some grave disadvantages which could not be overcome, so I looked forward to seeing soon some denial of Mr Poll's priority or some adverse criticism. Something of the kind may have appeared without my knowledge, for of late years I have neglected the study of craniology and have not followed its literature closely. At all events, I saw nothing more about Mr Poll's invention until I read a short notice by Mr Frank Russell in *THE AMERICAN ANTHROPOLOGIST* for February, 1898, page 52. As Mr Russell attributes the original invention to Mr Poll and highly praises the method, I felt the time had come to give the results of my own reading and experience.

The first person, as far as I can learn, who made experiments in the gauging of crania with the aid of a rubber bag was none other than the famous Paul Broca, and he performed them some time previous to May 16, 1872, for at that date he reported them to the Society of Anthropology. This was 24 years before the date of Poll's publication. Broca did not add the elaborate machinery of later experimenters, but I think he had everything at hand that was necessary to test the validity of the system. He made two series of experiments.

In the first series he used a thin india-rubber bag, holding, when not forcibly distended, a little over a liter of water (or less than the contents of the ordinary adult skull), but capable, under pressure of a column of water one meter high, of holding two

¹ Read before the Anthropological Society of Washington, May 17, 1898.

liters (or more than the contents of the cranial cavity). This bag was introduced empty through the foramen magnum and then filled with water. His first two trials seemed successful, but on the third trial the bag was torn on "the square plate which forms the posterior edge of the sella turcica." He caused a new and stouter bag to be made, but it shared the same fate as the first.

Hoping to avoid the chance of rupture, his second series of experiments was made with a rubber bag of larger capacity, under ordinary distension, than the largest normal skull—about two liters. He employed this with different degrees of pressure in the supplying tube, using at last a column of water two meters in height. Then he discovered that at certain points, where distension was extreme, the bag was about to burst, yet that the cranium was not completely filled; that empty spaces still remained, amounting in all to 49 cc.; so he came to the conclusion that the method was not practicable.

The second person to employ the system, and a true inventor of it, was Dr Wilhelm Friedrich Pacha. He seems to have made his first experiments in the year 1880, or 16 years before Poll's time. A brief notice of these was given by Dr Moritz Benedikt in 1884,¹ and a more extensive description, with illustrations, was given by the same author in 1888.² Perhaps he published other descriptions, but they have not come to my notice. At the time he wrote, Dr Benedikt was aware of Broca's experiments. He mentions them; yet, while he admits the failure of Broca's experiments, he claims success for those of Pacha. Both methods, as far as I can judge, must attain similar results. The difference is this: Broca used only the pressure of a standing column of water, while Pacha pumped the water into the bag by means of a complicated system of machinery—a system which seems to me unnecessarily elaborate, as far as I can judge without actual demonstration. Dr Benedikt does not convince us that this machinery removes the danger of rupture in skulls with sharp internal processes, or that it forces the bag fully into all the smaller fossæ at the base of the cranial cavity.

¹ Anzeiger der k. k. Gesellschaft der Aerzte in Wien, Nr. 31, Juni, 1884, p. 162.

² Kraniometrie und Kephalometrie, Vorlesungen gehalten an der Wiener Allgemeinen Poliklinik von Professor Moriz Benedikt, Wien und Leipzig, 1888.

The last paragraph of his article reads thus:

"There is no doubt that Pacha's method is that of the future, and that the genial young savant, whose career promised great mental results, cut short by an early death, left an enduring monument to science. The object of discussion will now be the concluding moment of the filling and the many details that need correction. This method meets all requirements."

This paper of Dr Benedikt was published, as I have said, in 1888; but 8 years later we find Mr Poll, of Berlin, reinventing the system, ignorant of the fact that Dr Pacha preceded him. This leaves us to fear that the method did not prove on further trial such a great success as Dr Benedikt predicted.

The third individual to invent this system has thus far not given the results of his labor to the world, but at this moment he proceeds to place himself on record.

In 1883 I began the study of the collection of crania in the Army Medical Museum at Washington. I soon became dissatisfied with the methods of measuring the cubic capacity of the cranium most in vogue—by means of shot and other granular substances. Not knowing the previous experiments of Broca, I used water on the unprotected skull, and soon found out for myself the disadvantages of this method. I tried quicksilver, but found it an unmanageable fluid. Then I thought of the possibility of using india-rubber bags. After a long correspondence with George Tiemann & Co., of New York, I at length, in May, 1884, procured from that firm a number of globoid bags of delicate tissue, of various sizes, some twice as large as the ordinary cranial capacity—about 3,000 cc. My intention in using the larger bags was that there should be little or no stretching; that the folds of the bag might fall easily into the minor fossæ of the cranial cavity without much forcible distension. Allowance was made for the pressure of a column of water of two feet only. On the whole, the experiments made had essentially the same conditions as those of Broca's second series, already described. Like Broca, I made allowance in gauging for the displacement of the bag itself.

My greatest fear in the beginning was that the folds of the bag would not fall well—or rise well, rather—into the fossæ at the base, and I soon found that they did not. I demonstrated this to my own satisfaction, at least, in the first place by using skulls

whose walls were broken in places and allowed an examination of the interior (of such skulls we had many). I found that the bag never quite filled the sella turcica; that if the crista galli were prominent the bag would not fill the anterior fossæ, but would bridge over a considerable space of these cavities near the median line, and that it did not always fill the anterior portions of the middle fossæ.

Not content with the results of observations made on fenestrated skulls, I tried the following plan on a bisected cranium. I smeared one of the bags with a mixture of unguent and lamp-black. Putting the bag into the cavity, I filled it with water in the usual manner. When it was withdrawn I studied the smearing on the inner table and found that the sella turcica and portions of the anterior fossæ had not been invaded by the bag.

In many of our Indian skulls the crista galli is sharp, strong, and prominent. In experimenting one day with such a skull the bag was ruptured on the point of the crista galli and the water escaped. I tried few experiments after this mishap. I was discouraged by the breaking of the bag, as Broca had been before me.

Had I increased the pressure as other observers have done, would I have overcome my difficulties with regard to the un-filled cavities? I had reason at the time to think I would not. If the bag ruptured on a sharp prominence with the little pressure I exerted, would not an increase of pressure have increased the chances of rupture?

Here I stopped. I came to the conclusion that while the method might do well for certain selected skulls, it would not answer for all or even for a majority. A method of limited application in craniometry is of little value.

I was urged at the time to publish the results of my work in order that I should establish priority to a method which possibly might be improved by future experiments, or in order, at least, to let others learn by my failures; but I felt so little satisfaction with what I had done that I never wrote an account of it until the present. I am glad now that I sought not to establish claims of priority. Had I sought this, I should have later learned with chagrin, instead of with a happy indifference, that I had no priority to claim.

Should any one be ungenerous enough to discredit me, I have

a little evidence to offer in my behalf. I have here one of the bags which I used in my experiments, rotten and brittle after an ignoble seclusion of fourteen years [here the bag was exhibited], and I have certified copies of the correspondence between me and the Messrs Tiemann & Co., taken from the archives of the Army Medical Museum. Mr David Flynn, who assisted me in my experiments, is still on duty at the Army Medical Museum, where he may be interviewed.

The fullest account of Poll's method that I have seen appeared in "Verhandlungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte" (1896, pp. 614-620). Mr W. Krause, who introduces the report, says "it is an entirely original and new apparatus." There may be something new in the minor accessories, but there is nothing new in the important elements. No doubt Mr Poll believed he had invented a totally new principle, but after he had demonstrated his principle to the public he learned that he had been anticipated. In a supplement to his report he says :

"Mr Paul Bartels was so kind as to point out to me the experiments, hitherto unknown to me, of Broca (*Mem. de la Soc. d'Anthrop. de Paris*, 1873, pp. 81 et 95. Compare also Pacha, Benedikt, Kraniometrie und Kephalometrie, 1888, p. 5), which at the time were not successful and for that reason not noticed."

Thus lightly does he pass over the works of his predecessors.

M Poll states that he has a reinforcement on one meridian of his rubber bag which prevents it from being torn ; but it seems to me that if the reinforcing piece is thick enough to prevent a tear it must also be thick enough to keep the bag from entering the sella turcica. Again, we think that the operator cannot feel assured that the reinforcement in all cases applies itself to the median line of the skull, where the danger from rupture lies. I hope that Mr Poll has succeeded in overcoming the difficulties which others have encountered in trying to establish this method, which seems at a first glance to promise so much for craniometry ; but I find nothing in his article nor in that of Mr Russell to make me feel assured that he will achieve a constant success. I hope the future may prove me a pessimist.

Dr Pacha used, as I have said, a very complicated apparatus, wherein he had an arrangement for holding the cranium with clamps, screws, springs, and levers, which it seems to me might

easily crush frail bones. Mr Poll uses a frame or craniophore of less complicated form. Perhaps he gains something for facility by this; but the necessity for it is not very evident to me. Broca apparently had nothing but a rubber bag, a funnel, and a measuring glass; but he seems with these to have accomplished his purpose and to have satisfied himself that the principle was faulty. I had little more than Broca. To hold the cranium steady, I had a pan filled with sand, in which I bedded the vertex as deeply as was necessary. In filling, I used an ordinary tin funnel with a fluted spout, which, I think, permitted the escape of all air from the bag. When I wished to empty the bag, I easily turned the cranium over on its side in the bed of sand and allowed the water to pour out. When the bag was nearly empty, I withdrew it from the cranial cavity, held it up by the bottom, and pressed it until its contents were fully drained into the measuring glass. I did not even use a stop-cock. When the filling was completed, I applied a clamp, such as photographers use in printing, to the tube at the level of the foramen magnum. All the water above this clamp was drained off before the measuring glass was produced. Had I been encouraged by my first experiments, I might have found it advisable to add some other appliances.

It is an interesting fact that within a period of 24 years four different individuals should have invented this system, each believing himself to be the original inventor.

Failing to successfully apply the india-rubber bags, I did not despair of eventually devising a plan for using water in some other way to measure the capacity of the cranium, so I spent some months in perfecting another method. In this I coated the outside of the skull with a thick layer of putty, which was removed while still soft, and I applied to the inside a thin varnish by means of an ether spray apparatus. I have not now time to dwell on minor particulars. A description of the method was read before the National Academy of Sciences April 22, 1885, and published in volume III of the memoirs of the Academy. I believe this method gave the most accurate results ever obtained; but I have not yet learned that in the thirteen years since it was perfected any one except the inventor has ever given it a trial. "And such," said Mr Pott, the illustrious editor of the *Eatans-will Gazette*, "is notoriety."